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JC490 U.S. PTO

11-02-00

A

Practitioner's Docket No. 712-002-104

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of
Inventor(s): Michael A. Davis and David R. Fournier

WARNING: 37 C.F.R. § 1.41(a)(1) points out:

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(i) is filed supplying or changing the name or names of the inventor or inventors."

For (title): OPTICAL SYSTEM FEATURING CHIRPED BRAGG GRATING ETALON
FOR PROVIDING PRECISE REFERENCE WAVELENGTHS

CERTIFICATION UNDER 37 C.F.R. § 1.10*

(Express Mail label number is mandatory.)

(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date November 1, 2000 in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EL 628 638 094 US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Debra A. Pongetti

(type or print name of person mailing paper)

Debra A. Pongetti

Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

***WARNING:** Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).

"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

(New Application Transmittal [4-1]—page 1 of 11)

JC825 U.S. PTO
09/703823
11/01/00

1. Type of Application

This new application is for a(n)

(check one applicable item below)

☒ Original (nonprovisional)

☐ Design

☐ Plant

WARNING: Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. § 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application

WARNING: Do not use this transmittal for the filing of a provisional application

NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

☐ Divisional.

☐ Continuation.

☐ Continuation-in-part (C-I-P).

2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)

NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:

(i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(f) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

WARNING: If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120, 121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

(New Application Transmittal [4-1]—page 2 of 11)

WARNING: When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application must be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).

- ☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed

A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

15 Pages of specification

4 Pages of claims

3 Sheets of drawing

WARNING: DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c).

(complete the following, if applicable)

- ☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).

☐ formal

☒ informal

B. Other Papers Enclosed

1 Pages of declaration and power of attorney

1 Pages of abstract

1 Other (title page)

4. Additional papers enclosed

☐ Amendment to claims

☐ Cancel in this applications claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☐ Preliminary Amendment

☐ Information Disclosure Statement (37 C.F.R. § 1.98)

☐ Form PTO-1449 (PTO/SB/08A and 08B)

☐ Citations

- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

5. Declaration or oath (including power of attorney)

NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).

NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).

☒ Enclosed

Executed by

(check all applicable boxes)

☒ inventor(s).

☐ legal representative of inventor(s).
37 C.F.R. §§ 1.42 or 1.43.

☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. See item 13 below for fee.

☐ Not Enclosed.

NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of all the above named inventor(s).

(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).

☐ Showing that the filing is authorized.
(not required unless called into question. 37 C.F.R. § 1.41(d))

(New Application Transmittal [4-1]—page 4 of 11)

6. Inventorship Statement

WARNING: If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

☐ The same.

or

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,

☐ is submitted.

☐ will be submitted.

7. Language

NOTE An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of \$130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).

☒ English

☐ Non-English

☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

8. Assignment

☒ An assignment of the invention to CiDRA Corporation doing business
at 50 Barnes Park North, Wallingford, CT 06492

☒ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☒ FORM PTO 1595 is also attached.

☐ will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters—one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

(New Application Transmittal [4-1]—page 5 of 11)

9. Certified Copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

☐ is (are) attached.

☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 C.F.R. § 1.16)

A. ☒ Regular application

CLAIMS AS FILED						
Number filed	Number Extra		Rate		Basic Fee 37 C.F.R. 1.16(a) \$ 710.00	
Total Claims (37 C.F.R. § 1.16(c))	15	- 20 =	0	×	\$ 18.00	0
Independent Claims (37 C.F.R. § 1.16(b))	1	- 3 =	0	×	\$ 80.00	0
Multiple dependent claim(s), if any (37 C.F.R. § 1.16(d))				+	\$270.00	

☐ Amendment cancelling extra claims is enclosed.

☐ Amendment deleting multiple-dependencies is enclosed.

☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).

Filing Fee Calculation \$ 710.00

B. ☐ Design application

(\$320.00—37 C.F.R. § 1.16(f))

Filing Fee Calculation \$

C. ☐ Plant application

(\$490.00—37 C.F.R. § 1.16(g))

Filing fee calculation \$

11. Small Entity Statement(s)

- ☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. § 1.9 and 1.27 is (are) attached.

WARNING: "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent and includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

WARNING: "Small entity status must not be established when the person or persons signing the . . . statement can **unequivocally** make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added)

(complete the following, if applicable)

- ☐ Status as a small entity was claimed in prior application _____ / _____, filed on _____, from which benefit is being claimed for this application under:

35 U.S.C. § ☐ 119(e),
☐ 120,
☐ 121,
☐ 365(c),

and which status as a small entity is still proper and desired.

- ☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of A, B or C above)

\$ _____

NOTE: Any excess of the full fee paid will be refunded if small entity status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

(complete, if applicable)

- ☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.

(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee \$ 710.00

☒ Recording assignment
(\$40.00; 37 C.F.R. § 1.21(h))
(See attached "COVER SHEET FOR
ASSIGNMENT ACCOMPANYING NEW
APPLICATION".) \$ 40.00

☐ Petition fee for filing by other than all the
inventors or person on behalf of the inventor
where inventor refused to sign or cannot be
reached
(\$130.00; 37 C.F.R. §§ 1.47 and 1.17(i)) \$ _____

☐ For processing an application with a
specification in
a non-English language
(\$130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) \$ _____

☐ Processing and retention fee
(\$130.00; 37 C.F.R. §§ 1.53(d) and 1.21(l)) \$ _____

☐ Fee for international-type search report
(\$40.00; 37 C.F.R. § 1.21(e)) \$ _____

NOTE: 37 C.F.R. § 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed \$ 750.00

14. Method of Payment of Fees

☒ Check in the amount of \$ 750.00

☐ Charge Account No. _____ in the amount of
\$ _____

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).

15. Authorization to Charge Additional Fees

WARNING: If no fees are to be paid on filing, the following items should not be completed.

WARNING: Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

- ☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 23-0442.

☒ 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)

☒ 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action

☒ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☒ 37 C.F.R. § 1.17(a)(1)–(5) (extension fees pursuant to § 1.136(a)).

☒ 37 C.F.R. § 1.17 (application processing fees)

NOTE: “. . . A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission.” 37 C.F.R. § 1.136(a)(3).

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires “Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . .” From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as “other than a small entity” and (b) no notification is required if the change is to another small entity.

16. Instructions as to Overpayment

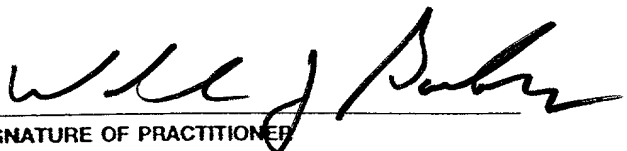
NOTE: "... Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

- ☒ Credit Account No. 23-0442
- ☐ Refund

Reg. No. 32,720

Tel. No. (203) 261-1234

Customer No. 004955



SIGNATURE OF PRACTITIONER

William J. Barber

(type or print name of attorney)

Ware, Fressola, Van Der Sluys & Adolphson LLP
755 Main Street, P.O. Box 224

P.O. Address

Monroe, Connecticut 06468

☐ **Incorporation by reference of added pages**

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)

- ☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added _____

- ☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added _____

- ☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added _____

- ☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added _____

☒ **Statement Where No Further Pages Added**

(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)

- ☒ This transmittal ends with this page.

UNITED STATES PATENT APPLICATION

of

Michael A. Davis,

and

David R. Fournier

for a

OPTICAL SYSTEM FEATURING CHIRPED BRAGG GRATING ETALON
FOR PROVIDING PRECISE REFERENCE WAVELENGTHS

EXPRESS MAIL NO. EL 628 638 094 US

CIDRA CORP. PROPRIETARY

**OPTICAL SYSTEM FEATURING CHIRPED BRAGG GRATING ETALON
FOR PROVIDING PRECISE REFERENCE WAVELENGTHS**

BACKGROUND OF INVENTION

5 1. Technical Field

The present invention relates to an optical system; and more particularly, to an optical system for providing reference wavelengths.

10 2. Description of Related Art

There exist many applications where a very accurate measurement of the wavelength of an optical signal is required, particularly in high sensitivity sensing applications where measurement of the movement of the Bragg grating reflected wavelength by less than a picometer is required. Several different techniques and instrumentation packages have been devised which have the capacity to measure multiple wavelengths with sub-picometer accuracy, however, often these systems require a minimum of one known reference optical signal which is used to maintain the accuracy of the measurements. In systems where the wavelength range of operation is large, a set of reference signals may be required to maintain the accuracy over the entire band.

For example, Figure 1 shows an optical signal generating scheme, which is based on the use of two broadband fiber Bragg gratings (FBGs) 6, 7 to form an etalon 8. Figure 1(a) and 1(b) show graphs of individual grating reflected spectrums of the Bragg gratings 6, 7 in the Bragg grating etalon shown in Figure 1. If the gratings 6, 7 are written at the same wavelength a cavity is formed inbetween, and inside of this cavity certain multiple frequencies will resonate. The spacing between the resonating frequencies is given by the equation:

$$\nu_F = \frac{c}{2d},$$

where c is the speed of light and d is an effective spacing between the gratings. Therefore, depending on the spacing between the gratings 6, 7 a comb spectrum (not shown) of narrow optical signals can be created. This comb can then provide the basis for a set of precise reference optical signals. However, the above equation only applies if the optical frequency in the cavity is within the resonant conditions of the two Bragg gratings 6, 7. If the optical frequency is outside this region, the light will pass through the cavity unaffected. In certain applications this

might be a desirable feature; however, for a set of reference optical frequencies, the unaffected light is undesirable. (Compare to the technique disclosed in United States Patent No. 5,892,582, hereby incorporated by
5 reference, where two mirrors are used to form an etalon.)

SUMMARY OF INVENTION

The problem in the prior art can be solved by chirping the Bragg gratings to produce a sufficiently broad Bragg grating etalon pair to cover all or most of the optical frequencies of interest. In so doing, all light entering the cavity will meet the resonance conditions of the Bragg grating etalon pair.

In particular, the present invention provides an optical system featuring a broadband source and a chirped Bragg grating etalon. The broadband source provides a broadband optical signal. The chirped Bragg grating etalon responds the broadband optical signal, for providing a chirped Bragg grating etalon optical signal having a precise
20 set of the optical reference signals.

The chirped Bragg grating etalon may include a pair of chirped Bragg gratings.

The precise set of the optical reference signals is determined by the spacing of the chirped Bragg gratings of

the chirped Bragg grating etalon. The precise set of the optical reference signals includes a series of peaks covering most of a source spectral width of the broad optical source signal with the power at the beginning and end of the spectrum passed unaffected by the chirped Bragg grating etalon due to the limited bandwidth thereof.

The optical system may also have an optical filter that responds to the chirped Bragg grating etalon optical signal, for providing an optical filter signal having the precise set of the optical reference signals. The optical filter includes an optical bandpass filter, an additional Bragg grating, a long period Bragg grating or a selective dielectric filter. When the optical bandpass filter is used, it responds to the chirped Bragg grating etalon optical signal, for providing an optical bandpass filter signal having the precise set of the optical reference signals.

In an alternative embodiment the optical filter may be in the form of a Bragg grating filter used in combination with an optical circulator (or coupler). In this case, the optical signal transmitted through the chirped Bragg grating etalon is introduced to the optical filter through the optical circulator (or coupler). The signal reflected from the optical filter has the precise set of the optical

reference signals and is then transmitted back through the circulator (or coupler) where it is presented to the user.

The present invention provides a technique for providing a well defined set of reference optical signals for use in systems where a very accurate measurement of the wavelength of an optical signal is required.

The foregoing and other objects, features and advantages of the present invention will become more apparent in light of the following detailed description of exemplary embodiments thereof, as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The drawing includes Figures 1-4, and the following is a brief description thereof:

Figure 1 is a diagram of a known optical system having a Bragg grating etalon; Figure 1(a) and 1(b) show graphs of a wavelength versus an individual grating reflected power spectrum of Bragg gratings in the Bragg grating etalon shown in Figure 1.

Figure 2 is a diagram of an optical system having a chirped Bragg grating etalon that is the subject matter of the present invention.

Figure 3 is a diagram of one embodiment of an optical system that is the subject matter of the present invention.

Figure 4 is a diagram of a chirped Bragg grating etalon and the broadband source similar to that shown in Figures 2 and 3; Figure 4(a) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the broadband source output signal shown in Figure 4; and Figure 4(b) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the chirped Bragg grating etalon shown in Figure 4.

Figure 5 is a diagram of the optical bandpass filter similar to that shown in Figure 3; Figure 5(a) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the chirped Bragg grating etalon shown in Figure 5; and Figure 5(b) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the optical bandpass filter shown in Figure 5.

Figure 6 is a diagram of an alternative embodiment to that shown in Figure 3 that is the subject matter of the present invention. Figure 6(a) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the broadband source shown in Figure 6; Figure 6(b) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the chirped Bragg grating

etalon shown in Figure 6; and Figure 6(c) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the circulator shown in Figure 6.

Figure 7 is a diagram of an alternative embodiment to that shown in Figure 3 that is the subject matter of the present invention. Figure 7(a) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the broadband source shown in Figure 7; Figure 7(b) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the chirped Bragg grating etalon shown in Figure 7; and Figure 7(c) shows a graph as a function of a wavelength versus a power spectrum of an output signal from the coupler shown in Figure 7.

DETAILED DESCRIPTION OF THE INVENTION

Figure 2: The Basic Invention

Figure 2 shows the basic invention, which provides an optical system generally indicated as 10 featuring a broadband source 12 and a chirped Bragg grating etalon 14.

The broadband source 12 provides a broadband optical signal. The broadband source is known in the art, and the scope of the invention is not intended to be limited to any particular kind or type thereof.

The chirped Bragg grating etalon 14 responds to the broadband optical signal, for providing a chirped Bragg grating etalon optical signal having a precise set of the optical reference signals to an optical fiber 18.

5 The chirped Bragg grating etalon 12 may include a pair of chirped Bragg gratings 14a, 14b, which are known in the art, formed in the optical fiber 18. A person skilled in the art would appreciate that the chirped Bragg gratings 14a, 14b will typically have a grating period that is about 1-2 microns, which is substantially shorter than a corresponding long-period Bragg grating. In contrast, long-period fiber gratings typically couple light from a core mode to a cladding mode, and have a grating period of about 10-100 times greater than the short-period grating. The scope of the invention is not intended to be limited to any particular chirped Bragg grating.

10 The precise set of the optical reference signals is determined by the spacing of the chirped Bragg gratings 14a, 14b in the chirped Bragg grating etalon 12. As shown and discussed in relation to Figure 4(b), the precise set of the optical reference signals includes a series of peaks covering most of a source spectral width of the broad optical source signal with the power at the beginning and

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end of the spectrum passed unaffected by the chirped Bragg grating etalon due to the limited bandwidth thereof.

The optical system 10 may also have an optical filter 16 that responds to the chirped Bragg grating etalon optical signal, for providing an optical filter signal having the precise set of the optical reference signals. The optical filter 16 includes an optical bandpass filter, an additional Bragg grating, a long-period Bragg grating or a selective dielectric filter, such as a Bragg grating.

In an alternative embodiment, the optical filter may be in the form of a Bragg grating filter used in combination with an optical circulator, as discussed below in relation to Figure 6.

Figures 3, 4, 4(a), (4b), 5(a), 5(b)

Figure 3 shows one embodiment of an optical system generally indicated as 50 featuring a broadband source 52, a chirped Bragg grating etalon 54 and an optical bandpass filter 56. See also Figure 4.

Similar to that discussed above, the broadband source 52 provides a broadband optical signal. The chirped Bragg grating etalon 54 includes a Bragg grating etalon pair 54a, 54b, formed in an optical fiber 58, that responds to the broadband optical signal, for providing a chirped Bragg

grating etalon optical signal having a precise set of the optical reference signals to the optical fiber 58.

The optical bandpass filter 56 responds to the chirped Bragg grating etalon optical signal, for providing an optical bandpass filter signal having the precise set of the optical reference signals.

In operation, the chirped Bragg grating etalon 54 is illuminated by the broadband source 52 with the transmitted signal passing through the optical bandpass filter 56 to produce the desired spectrum as shown and described in relation to Figure 4(b), which shows the optical characteristics of such a device when illuminated with broadband light.

As described above, the Bragg gratings 54a, 54b of the chirped Bragg grating etalon 54 are written with sufficient bandwidth to cover most of the optical frequencies in the broadband source 52. The throughput of the chirped Bragg grating etalon 54 produces a series of peaks covering most of the source spectral width with the power at the beginning and end of the spectrum passed unaffected by the device due to the limited bandwidth of the chirped Bragg gratings 54a, 54b. The optical power not transmitted by the chirped Bragg grating etalon 54 is reflected back towards the source. Additionally, the number of peaks in a given optical

frequency range is customizable, since the spacing between the chirped Bragg gratings 54a, 54b (parameter d in equation 1 above) determines the spacing of the optical peaks or comb. If the peaks are accurately measured and a calibration is obtained for the etalon, the transmitted optical spectrum can then serve as the basis for a precise set of optical references.

To achieve the final comb of optical frequencies, the power which remains in the beginning and end of the source spectral profile must be eliminated. This can be achieved through the use of an optical filter, such as the optical bandpass filter 56, to pass only the central strong peaks which a system can reliably detect.

Figure 5(b) shows a final filtered output from the optical bandpass filter 56.

Figure 6

Figure 6 shows an alternative design generally indicated as 100 having a broadband source 102, a chirped Bragg grating 104 with chirped Bragg gratings 104a, 104b, an optical circulator 106, an optical fiber 108, and a filter Bragg grating 110. The broadband source 102 and the chirped Bragg grating etalon 104 with chirped Bragg gratings 104a,

104b operate similar to that discussed above in relation to Figures 2-4 above.

In this embodiment, the optical filter may be in the form of the Bragg grating filter 110 used in combination with the optical circulator 106. The transmitted signal from the chirped Bragg grating etalon 104 is passed through the circulator 106 (into port 1, out port 2) and onto the filter Bragg grating 110. The filter Bragg grating 110 acts as a selective reflective filter to only reflect the peaks of interest. The reflected signal is directed back through the circulator 106 and is output on port 3.

A person skilled in the art would appreciate that an optical coupler could be used in place of the circulator (Figure 7) to produce the same result.

Figure 7

Figure 7 shows an alternative design generally indicated as 200 having a broadband source 202, a chirped Bragg grating 204 with chirped Bragg gratings 204a, 204b, an optical coupler 206, an optical fiber 208, and a filter Bragg grating 210. The broadband source 202 and the chirped Bragg grating etalon 204 with chirped Bragg gratings 204a, 204b operate similar to that discussed above in relation to Figures 2-4 and 6 above. In this embodiment, the optical

filter may be in the form of the Bragg grating filter 210 used in combination with the optical coupler 206. The transmitted signal from the chirped Bragg grating etalon 204 is passed through the coupler 206 and onto the filter Bragg grating 210. The filter Bragg grating 210 acts as a selective reflective filter to only reflect the peaks of interest. The reflected signal is directed back through the circulator 206 and is output port.

Temperature and Strain Compensation

The Bragg gratings 14a, 14b; 54, 54b; 104a, 104b; 204a, 204b as well as the etalon 14; 54; 104; 204 itself, are temperature and strain sensitive such that either of those two parameters will change the optical characteristics of the comb spectrum passed by the overall system or device 10; 50; 100; 200. If the comb must be used as absolute wavelength references, then these two parameters must be controlled or eliminated in the etalon 14; 54; 104; 204 or conversely the parameters must be externally measured and an appropriate correction factor applied to the measured references.

In a first approach, the overall system or device 10; 50; 100; 200 could be placed in a temperature compensating package, such as that described in United States patent

application serial no. 09/519,240, filed March 6, 2000,
entitled "Temperature Compensated Optical Device," hereby
incorporated by reference herein. This package would
isolate the device from any external strain while
5 additionally providing a method to compensate for any
temperature induced changes in the device. The temperature
compensation can be done using a variety of methods, such as
packaging the device using a material which would induce a
strain on the device to exactly cancel the effects of
temperature.

Alternatively, a strain isolated package could be used
and the temperature of the overall package could be
controlled using a precision controller, such as a thermal
cooler/heater element (TCE) which is known in the art.

A simpler approach would be to place the device in a
strain isolated package and use a precise measurement of the
temperature of the package to correct any changes. See
United States patent application serial no. 09/448,367,
filed November 23, 2000, entitled "Grating Reference Sensor
20 for Precise Reference Temperature Measurement," hereby
incorporated by reference herein. A calibration of the
device would be required over the operation range of the
device and then used to provide the correction during use.

In all configurations of the system or device, care must be taken to prevent strain gradients from occurring over the length of the etalon. Such gradients will induce errors which cannot easily be corrected. Additionally, care must be used in the attachment process used to attach the etalon to the outer package. Creep in the attachment or drift due to effect such as coatings on the device and annealing must be eliminated to maintain the accuracy required. Various packaging schemes can be used, such as encapsulation of the annealed stripped etalon in a quartz shell that can provide a creep free attachment means.

Scope of the Invention

Although the invention has been described and illustrated with respect to exemplary embodiments thereof, the foregoing and various other additions and omissions may be made therein and thereto without departing from the spirit and scope of the present invention.

WE CLAIM:

1. An optical system, comprising:

a broadband source for providing a broadband optical signal; and

5 a chirped Bragg grating etalon, responsive to the broadband optical signal, for providing a chirped Bragg grating etalon optical signal having a precise set of the optical reference signals.

10 2. An optical system according to claim 1, wherein the chirped Bragg grating etalon includes a pair of chirped Bragg gratings.

15 3. An optical system according to claim 2, wherein the precise set of the optical reference signals is determined by the spacing of the chirped Bragg gratings of the chirped Bragg grating etalon.

4. An optical system according to claim 1, wherein the precise set of the optical reference signals includes a series of peaks covering most of a source spectral width of the broad optical source signal with the power at the beginning and end of the spectrum passed unaffected by the chirped Bragg grating etalon due to the limited bandwidth thereof.

5. An optical system according to claim 1, wherein the optical system further comprises an optical filter that responds to the chirped Bragg grating etalon optical signal, for providing an optical filter signal having the precise set of the optical reference signals.

6. An optical system according to claim 5, wherein the optical filter includes an optical bandpass filter.

7. An optical system according to claim 5, wherein the optical filter includes an additional Bragg grating.

8. An optical system according to claim 5, wherein the optical filter includes a long-period Bragg grating.

9. An optical system according to claim 5, wherein the optical filter includes a selective dielectric filter.

10. An optical system according to claim 9, wherein the selective dielectric filter is a Bragg grating.

11. An optical system according to claim 1, wherein the optical system further comprises an optical bandpass filter that responds to the chirped Bragg grating etalon optical signal, for providing an optical bandpass filter signal.

12. The optical system according to claim 1, further comprising:

an optical filter, responsive to the chirped Bragg grating etalon optical signal, for providing at least a portion of the precise set of the optical reference signals to an output port.

13. The optical system according to claim 12, further comprising:

an optical directional device for directing the chirped Bragg grating etalon optical signal to the optical filter, and directing the at least a portion of the precise set of the optical reference signals to the output port.

14. The optical system according to claim 13, wherein the optical directional device includes one of an optical circulator and an optical coupler.

5 15. The optical system according to claim 12, wherein the optical filter includes a Bragg grating filter for reflecting the at least a portion of the precise set of the optical reference signals to an output port.

ABSTRACT OF THE DISCLOSURE

5 An optical system has a broadband source and a chirped Bragg grating etalon. In operation, the broadband source provides a broadband optical signal. The chirped Bragg grating etalon responds to the broadband optical signal, for providing a chirped Bragg grating etalon optical signal having a precise set of the optical reference signals. The chirped Bragg grating etalon may include a pair of chirped Bragg gratings. The precise set of the optical reference signals is determined by the spacing of the chirped Bragg gratings of the chirped Bragg grating etalon. The precise set of the optical reference signals includes a series of peaks covering most of a source spectral width of the broad optical source signal with the power at the beginning and end of the spectrum passed unaffected by the chirped Bragg grating etalon due to the limited bandwidth thereof.

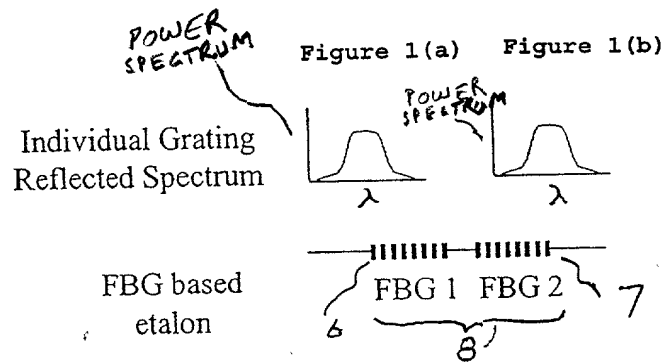


Figure 1: Prior art Optical System

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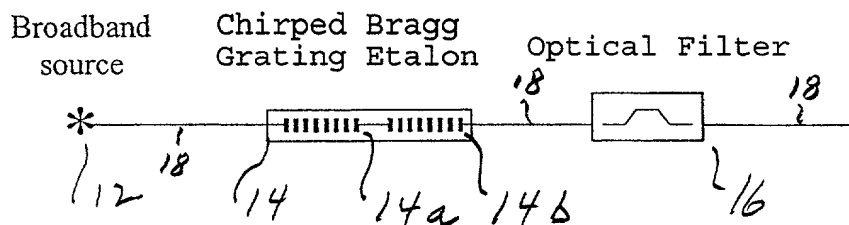


Figure 2: The Basic Invention

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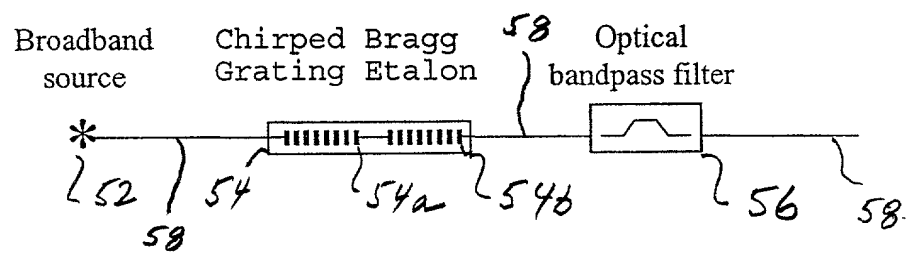


Figure 3: An Optical System

Figure 4: Chirped Bragg Grating Etalon and Broadband Source Combination

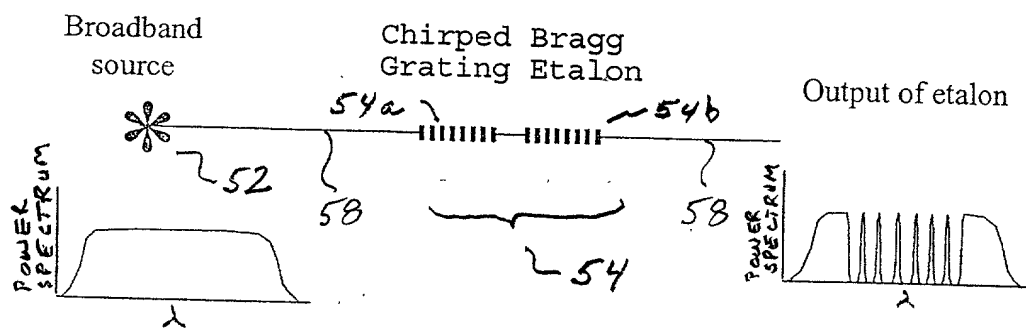


Figure 4(a)

Figure 4(b)

Figure 5: The Optical Bandpass Filter

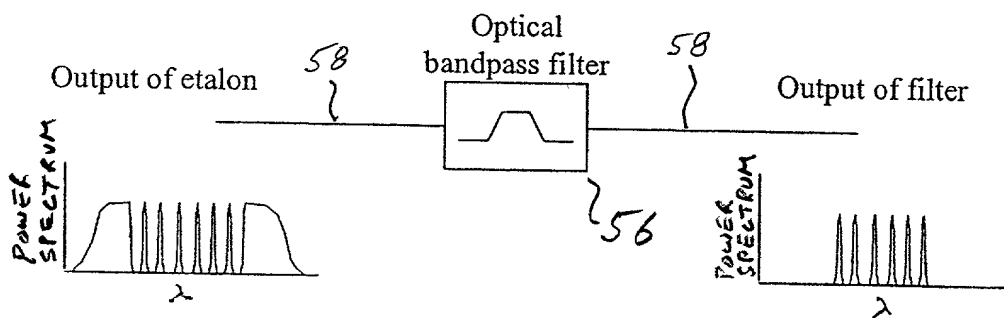
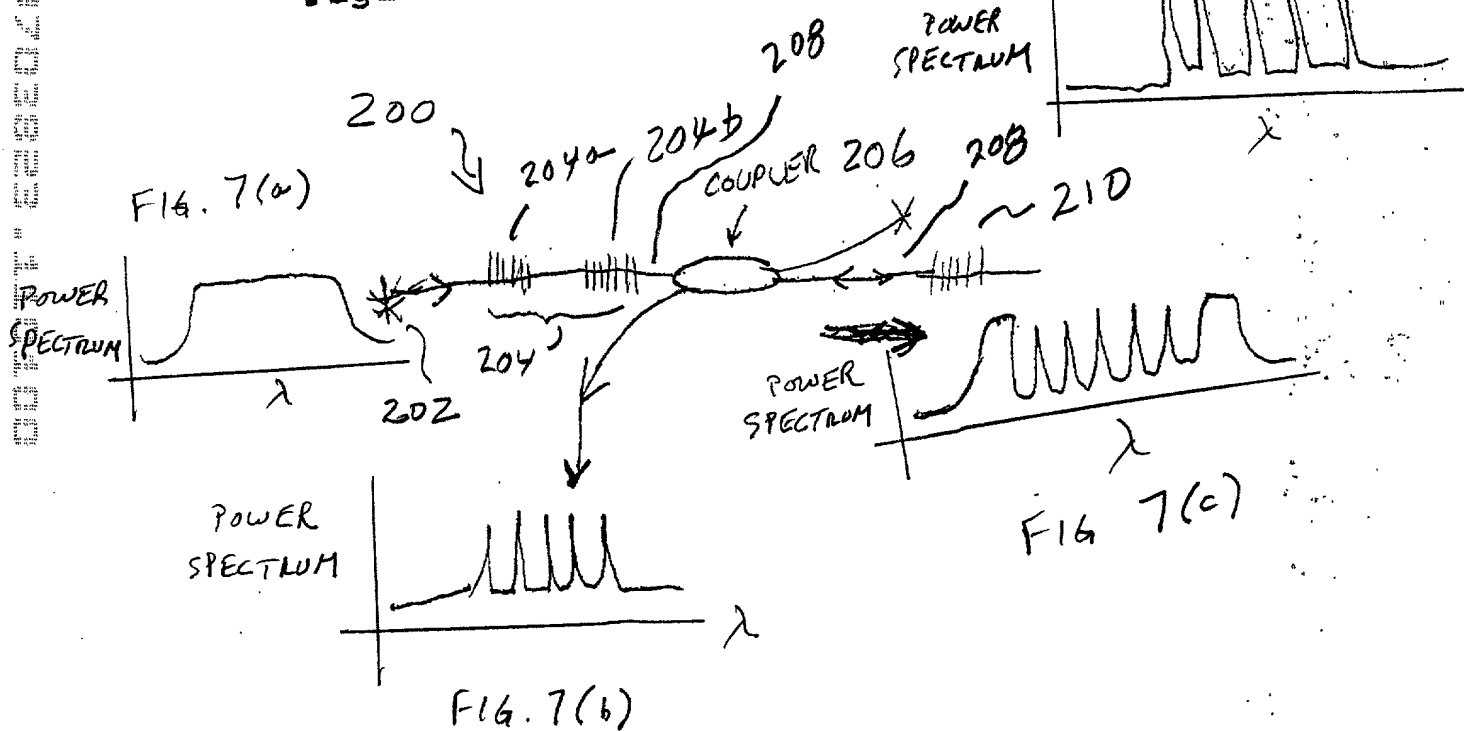
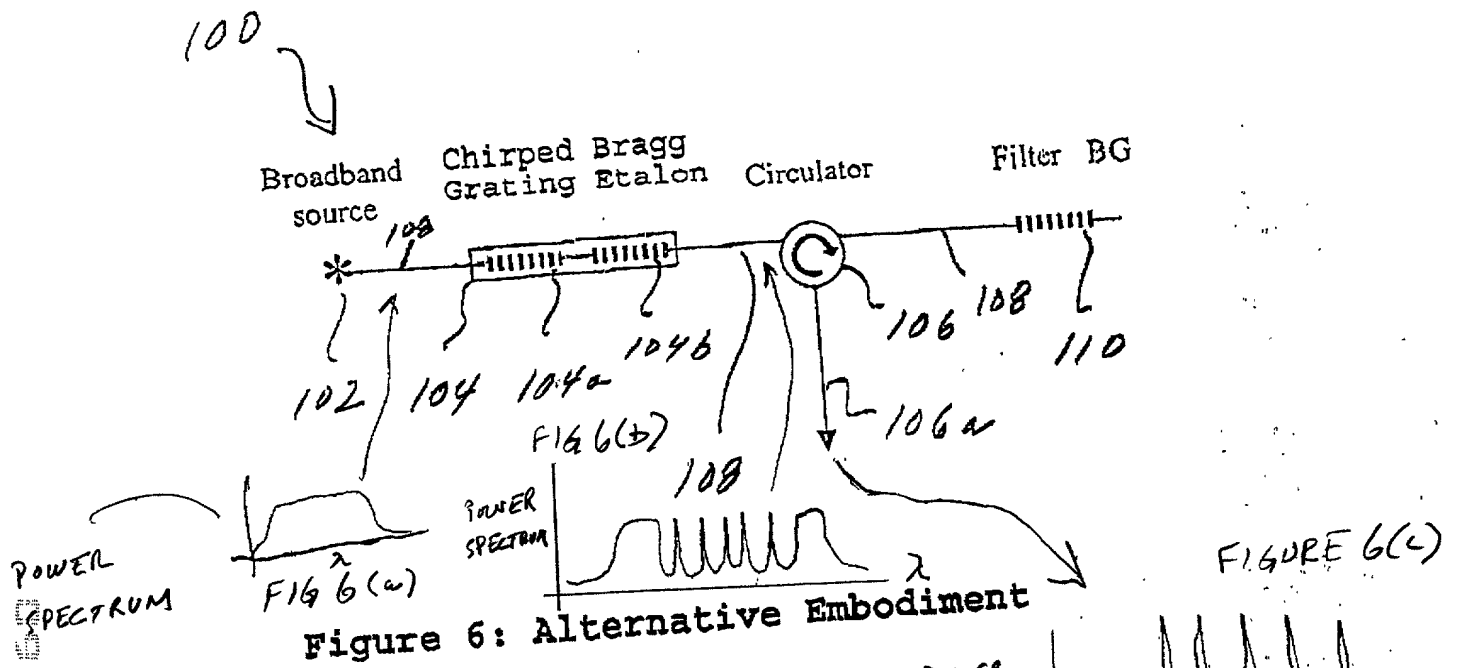


Figure 5(a)

Figure 5(b)



COMBINED DECLARATION AND POWER OF
ATTORNEY IN ORIGINAL APPLICATION

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712-002.104/
CC-0166

I declare: that my residence and citizenship is as stated below next to my name; that I believe I am the original, first and sole inventor (if only I am named below) or joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought in the specification identified as Attorney Docket No. 712-002.104/CC-0166 entitled **OPTICAL SYSTEM FEATURING CHIRPED BRAGG GRATING ETALON FOR PROVIDING PRECISE REFERENCE WAVELENGTHS**, that I have reviewed and understand the contents of the above-identified specification, including the claims; that I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in 37 C.F.R. §1.56; that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

I appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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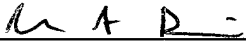

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